International Journal of Mechanical and Production
Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 8, Issue 2, Apr 2018, 87-92

EXPERIMENTAL INVESTIGATIONS ON DUAL BIO-FUEL (PINE BIODIESEL AND PALM BIODIESEL) BLENDED WITH DIESEL ON A SINGLE CYLINDER DIESEL ENGINE

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ABSTRACT

When the world, which we live in is looming with a severe energy crisis, in the near future with the perennial rise in petroleum price and depleting state of fossil fuel resources that may lead us to devastating consequences affecting the global economy, there is a need to study and discover home grown biodiesel that can fulfill our energy needs. Biodiesel obtained from vegetable oils are considered to be a promising alternate fuel. Last ten years, several researchers have been analyzed single biodiesel blends experimentally while researches on a combination of two different bio-fuel blends with diesel which have a larger scope is very little. The present study was taken up with two bio-fuels from Pine oil and Palm oil was analyzed at various ratios mixed with diesel. The effects of pine and palm oil bio-fuel were examined in an engine and the CO, HC, NO_x and smoke opacity were also investigated. During the investigation, it was observed that the brake thermal efficiency of biodiesel blends to be higher than diesel. Dual biodiesel blends were found to be suitable to conventional diesel fuel in all aspects such as emissions and performance. Further, from the investigation, it was seen in blend C there has been a reduction of 26.6% in the fuel consumption, while there has also been a reduction of 69%, 19% and 15.9% in HC, CO and smoke, respectively and at the same time, there has been an increase of 7 % of the oxides of nitrogen.

KEYWORDS: Fuel, Blend, Diesel, Single Cylinder, Diesel Engine & Plam

Received: Dec 10, 2017**; Accepted:** Jan 31, 2018**; Published:** Feb 24, 2018**; Paper Id.:** IJMPERDAPR20189

Original Article

INTRODUCTION

Diesel engines are extensively used to owe to their excellent drivability and fuel economy in the transportation and agricultural industry sectors[1,2]. Level of air pollution and greenhouse gases emission are now a wide concern due to their use[3,4]. Indirectly, diesel engine contributed via incomplete combustion that release polluted hazardous gases like carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), unburned hydrocarbon (HC) and smoke[5]. In the same way, it could affect human health, and this is a serious risk to the environment eventually[6]. Thus, the research and development of alternative fuels for transportation are preferable studies area on the applicability of clean energy technologies[7].

A lot of research work pointed out that biodiesel has received a significant attention and it is a possible alternative fuel[8]. Biofuel blends with diesel were employed as a fuel for diesel engine without any modifications in the existing engine[9,10]. Mixing biodiesel with diesels are a common research have been studied extensively, dual biodiesel blends with diesel are one of the latest attempt as part of renewable alternative energy sources solution with environmentally friendly characteristics in contrast to fossil fuels[11]. The work has started but is at preliminary stage, it known fact that duel biodiesels are under oxygenated fuel categories and many believe that oxygenated fuel into diesel could improve the combustion efficiency. The fatty acid methyl esters (FAME) based on vegetable oil generally called biodiesel as a fuel substitute to reduce environment pollution produced by the diesel engine. The bio-fuel produced from vegetable oils reacting with an alcohol in the presence of a catalyst is considered to be renewable sources and also methyl esters and glycerol were produced due to these reactions. A lot of research work pointed out that biodiesel has received a significant attention and it is a possible alternative fuel[12,13].

From the review of literatures, numerous works using biodiesel and its blends in engines have been done. However, most of the literatures focused on single biodiesel and its blends. From previous studies, it is evident that single biodiesel offers acceptable engine performance and emissions for diesel engine operation. Very few experiments have been conducted with the combinationof dual biodiesel and diesel as a fuel. So, the Pine oil and Palm oil were selected for this current study which is easily and locally available. As a first level of experimentation, the properties of above said fuels in various combinations were found out in this work. Hence, it is decided to select Pine oil methyl ester and Palm oil methyl ester with diesel as the fuel for this current analysis[14, 15]. The experimental results were compared with diesel with respect to exhaust emissions on a diesel engine.

MATERIALS AND METHODS

For this study, we have used Pine Oil Methyl Ester (PIN) and Palm Oil Methyl Ester (PAM) which are bio-fuel. Pine oil is obtained from the resins of pine tree while theother is from the fruits of Palm tree. Pine oil, is less viscous fuel. Pine oil, an alicyclic hydrocarbon, consists mainly of terpineol ($C_{10}H_{18}O$) along with alpha-pinene ($C_{10}H_{16}$) and terpene alcohols. Pine oil on compared to diesel has inherent oxygen, with lower molecular weight and shorter carbon chain length since the latent heat of vaporization of pine oil is not higher like lower alcohols, this does not produce any cooling effect like methanol and ethanol.

Palm oil contains better fuel properties reported by the few researchers, yet very little literature survey has been revealed on this field. Another reason for choosing this oil is the India is the second largest producer of palm oil. The two biodiesel (pine oil methyl ester and palm oil methyl ester) is prepared by the transesterification process. The dual biodiesel blends were prepared in different proportions. The various properties like kinematic viscosity, calorific value, flash point temperature, density and Cetane index of baseline fuel and two biodiesel mixed blends were determined by using ASTM methods and compared with diesel properties as shown in Table 1. The testing conducted on a stationary four stroke air cooled diesel engine with electrical loading and the emission characteristics were compared with baseline data of diesel fuel. Tests were conducted at a constant speed and at varying loads for all dual biodiesel blends. Engine speed was constant at 1500 rpm (rated speed) during all experiments. Three experiments for each load were carried out for accuracy. Fuel consumption and exhaust gas temperatures were also measured. The opacity of the exhaust gases was measured by the AVL make a smoke meter. The exhaust emissions were measured by the AVL make five gas analyzers. The experimental setup is shown in Figure1 and the detailed engine specifications are reported in Table 2.

Table 1: Properties of Fuels

Blend Name	Density @ 15°C (kg/ml)	Kinematic Viscosity @ 40°C (cst)	Flash Point °C	Calculated Cetane Index	Gross Calorific Value (MJ/kg)
Diesel (D)	0.822	3.52	74	50	42.7
70%D + 30% PIN(Blend A)	0.8427	2.15	60	32	42.78
70%D+25% PIN + 5% PAM (Blend B)	0.8438	2.31	62	33	42.92
70%D + 20% PIN + 10% PAM (Blend C)	0.8518	2.68	63	34	43.01

Figure 1: Experimental Setup

Table2: Engine Specifications

Number of Cylinder	One
Cylinder Bore (mm)	87.50
Power (kW)	5.20
Speed (rpm)	1500
Stroke Length (mm)	110.00
Connecting rod length (mm)	234.00
Compression Ratio	17.50
Swept Volume (cc)	661.45

RESULTS AND DISCUSSIONS

Table 1 shows the calorific value of different fuels. The calorific value of the biodiesel is lower than diesel. The 70%D+20%PIN+10%PAM blend has a higher calorific value than other blends. By blending the dual biodiesel with diesel, the calorific values of 70%D+20%PIN+10%PAM were increased 0.3MJ/kg which is more than single biodiesel blends. Hence, dual biodiesel and its blends are utilized to analyze the performance and emission analysis experimentally. Calibrated Redwood Viscometer is used for determining the kinematic viscosity. ASTM D0445 procedure is followed to analyze the viscosity of fuels. The viscosity of the blends decreases with the dual biodiesel blends and they are lower than diesel fuel.

Performance Analysis

The effect of load on fuel consumption is shown in Figure2. As load increases the FC reduces for all the dual biodiesel blends. For the full load, the value of fuel consumption (FC) of Blend A is 0.3 kg/hr, Blend B is 0.24 kg/hr, and Blend C is 0.22 kg/hr whereas diesel fuels have 0.36 kg/hr. The lower specific fuel consumption for the dual biodiesel fuel consumption is because of the higher calorific value of the blends. Fuel consumption was used for comparing engine performance of fuels with different calorific values. Figure 2 signifies the energy consumption for dual biodiesel blends and diesel. It shows that the Blend C is the lowest for all dual biodiesel blends compared with diesel. The lower energy

content is the reason for high fuel consumption, compared to diesel.

Consumption of fuel by an engine depends largely on its design and operating parameters, and the properties of the fuel this is used. Pine oil and palm oil have favorable properties like lower viscosity and higher calorific value as compared to diesel, this helps in reducing the fuel consumption. The fuel consumption for Blend C was observed to be lower than diesel, while the fuel consumption for Blend A and B remained comparable to diesel. The combined properties of pine oil and palm worked favorably for Blend B and Blend C, as the lower viscosity and higher calorific value of palm was sufficiently compensated by the improved properties of pine oil. In Figure 3, we can see that there is an improvement in BTE for Blends than diesel on account of better atomization and fuel/air mixing process. Owing to the reduction in viscosity of the blends there is increased atomization, vaporization and combustion. Further, the presence of oxygen in the palm oil, along with improved evaporation has assisted in achieving more complete combustion, increasing the BTE of the engine. However, the BTE of the engine was found to be lower for Blend A at full load than diesel.

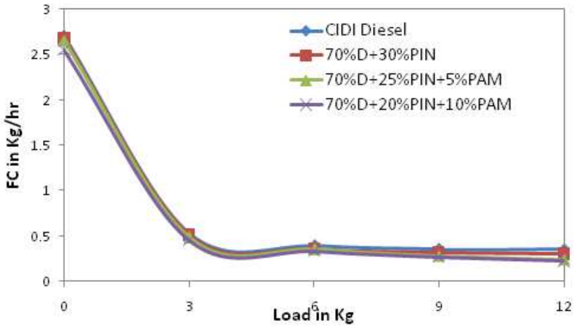

Figure 2: Fuel Consumption Vs Load

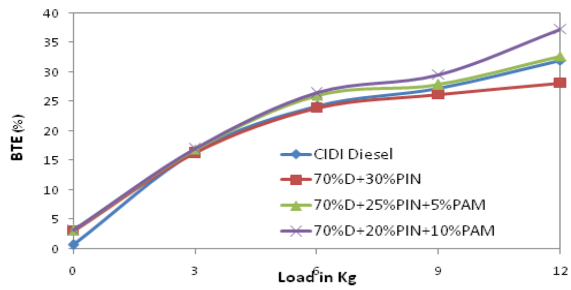

Figure 3: Brake Thermal Efficiency Vs Load

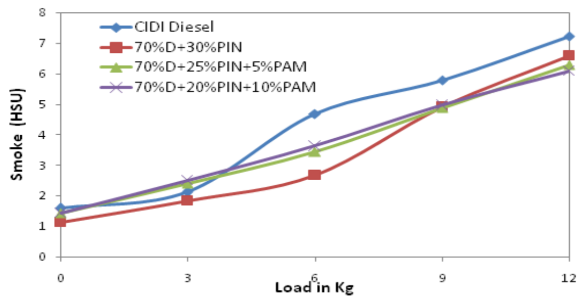

Figure 4: Smoke Vs Load

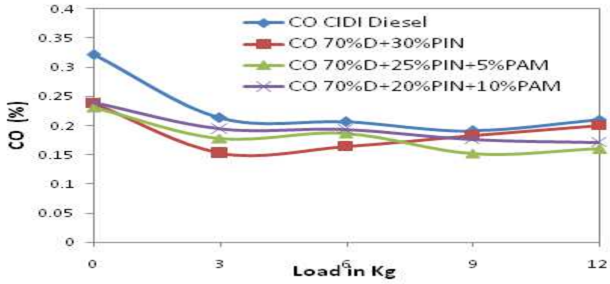

Figure 5: Carbon-monoxide Vs Load

It is observed from Figure 4, that the smoke percentage decreases with the increase in load. For the maximum load, the smoke for diesel was 7.23, whereas the Blend A gives 6.58, Blend B gives 6.29 and Blend C gives 6.08 HSU with the same maximum load. Blend A has a closer smoke value with diesel. In other blends, the smoke percentage was less than the diesel with the same load. The lower viscosity may be the reason for less smoke compared to diesel. The higher viscosity of pure biodiesel supports the fuel atomization which in turn increases the smoke. The variations of load on Carbon monoxide are shown in Figure 5. Carbon monoxide's (CO) content is decreasing with load. Blend C and Blend D give lower CO at full load than diesel; this is due to the oxygen contents in the biodiesel, which makes easy burning at higher temperatures in the cylinder. Blend A deviated from other biodiesels and shows higher side for higher loads. In engine load is higher, the lean fuel-air mixture is burned and thus less CO is produced.

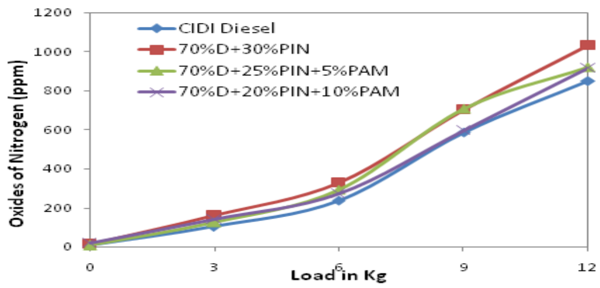

Figure 6: Oxides of Nitrogen Vs Load

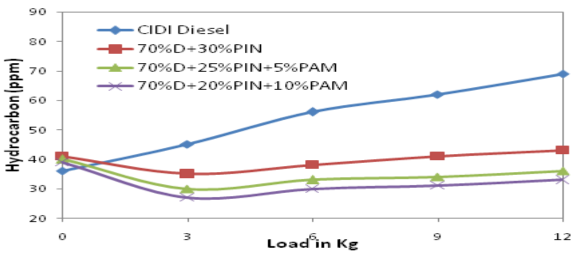

Figure 7: Hydrocarbon Vs Load

The effect of load on nitrogen oxides is shown in Figure 6. The nitrogen oxides (NOx) increased by increasing the load for each blend. For the maximum load, Blend A gives 1032 ppm whereas diesel gives 850 ppm, Blend B gives 920 ppm, and blend C gives 915 ppm at the same maximum load. From the results, NOx emission is lower for diesel than biodiesel blends. However, Blend C gives lesser NOx than other dual biodiesel blends.

Figure7 shows that, the relation between load and hydro carbon (HC) increased by increasing the load for diesel. All the blends give lower HC than diesel. From the results, Blend C gives lesser HC than other blends at full load. The

diesel generally produces less hydrocarbon emission atlower loads and higher emission at higher engine loads due to the relatively less oxygen available for the reaction[15].

CONCLUSIONS

Single cylinder diesel engine ran successfully during tests on dual biodiesels and its blends. The blends of diesel and the dual biodiesels of pine and palm methyl esters were characterized for their various emission and physical properties. From the experimental analysis results, the thermal efficiency of Blend B and C were higher than the diesel. Blend A were very close to the diesel values. The specific fuel consumption values of dual biodiesel blends were less than diesel. Blend A produced slightly lower CO than diesel at full load. In the case of Blend B and Blend Cthe CO emission is much lower than diesel at all loads. This is a considerable advantage over diesel while using the dual biodiesel blends. The dual biodiesel blends gave lower smoke opacity and higher oxides of nitrogen than diesel. Therefore, it may be reported that dual biodiesel blends of Blend B and Blend C would be used as an alternative fuel for diesel in the diesel engines. Various dual biodiesel blends with diesel can be focused for further recommendations.

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